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THE DECOMPOSITION RATE OF *DACTYLIS GLOMERATA* GRASS LITTER IN MEADOW ECOSYSTEMS DIFFERING IN AGE AND MANAGEMENT

ABSTRACT: The way of grass (*Dactylis glomerata)* aboveground parts decomposition on meadows differing both in age and management was compared. The investigations were carried in mosaic landscape (Suwałki Landscape Park) in north-eastern Poland. Experiment with using the identical for all meadows substratum (sand) for comparing the litter loss rate between meadows was carried. During three years studies (1987–89) it was found that landscape relief, age and management of meadow use influenced the rate of litter loss. Decomposition of litter on sandy substrate clearly reflected the course of its decompsition on soil surface but the values of loss rates were lower than on soil.

KEY WORDS: meadows, diversity, litter, mineralization.

1. INTRODUCTION

The decomposition of litter in meadow ecosystems is dependent on the quality and quantity of plant matter entering into the process of decomposition. It is generally considered that the more productive the site the greater its cellulolytic activity (Rychnovská 1993). The interactions between soil moisture, temperature, soil type and meadow management also influence decomposition process (Jakubczyk 1976, Breymeyer 1990, Rychnovská 1993).

The litter weight loss method may give much information concerning potential saprophagic activity in a soil.

It has been found that the application of single-species grass litter at different sites in different experimental treatments may give a reliable comparison of breakdown processes on meadows differing in terms of landscape, age and management.

The aim of the present research was to assess the course of the loss of litter on meadows differing in management practice, age and landscape location (relief and chemical properties of soil). In addition a field experiment compared the changes in the decomposition of litter on a sand substratum identical in all sites.

2. STUDY AREA

The research was done on the meadow of Suwałki Landscape Park (SLP) (north-east Poland) in the years 1987–1989 (Kajak 1997). Investigations were carried on in meadows differing in the length of time since establishment, as well as permanent meadows. The meadows were on outwash plain in the south-western part of SLP. They formed a series of meadows of the order Arrhenatheretalia from a very young meadow (LA – one year old crop of *Dactylis glomerata*, through typical communities of this order (several year old meadows – LB and many year old meadows – LC, to permanent meadows – P belonging to the community *Anthylli trifolietum montani* (Jankowski 1997). The meadows studied were formed by agricultural practices and the most important aspect was the time of establishment, defining age and influencing the type and intensity use and cultivation in successive years. In the first years after establishment, these meadows are mainly used as mown cocksfoot meadows and only partly grazed. Older meadows are grazed to a greater extent, with a limitation or cessation of mowing. The permanent meadows were situated on areas unfavourable to agricultural treatments. These meadows are very rich, multi-species communities with a developed sod and litter. Detailed data on the age of the studied meadows, management and location are given in Table 1.

All of the meadows studied are on true brown soils with a large proporton of gravel and stones, and a considerable (10–20%) dusty fraction (Łakomiec et al. 1991, Kusińska and Łakomiec 1997). Meadows of the sequence $LB_{2(4)}$, LB_3, LC_2, P_3 are distinguished by a deeper accumulation profile (0–50 cm), while those of the sequence LA, LB, $LB_{2(6)}$, LC, P and P_2 have a shallower accumulation layer (0–24 cm) (Łakomiec et al 1991).

A characteristic feature of the studied sequence of meadows is that older ones have a lower proportions of *Dactylis glomerata* in the sward and greater numbers of other species (Jankowski 1997). Older meadows also have a greater content of organic matter in the soil (Kusińska and Łakomiec 1997).

The microbiological research of Stefaniak et al (1997a) shows that the older meadows studied have greater microbial stability – expressed through the development of an autochtonous microflora, reduced respiratory activity and a greater activity of extracellular enzymes, especially cellulases.

Three sequence of meadows were chosen for research of the rate of weight loss of litter. The study sites formed three succesional sequences of 2–4 meadows analysed in different years. They ranged from simplified one (LA) or several years old leys (4–7) (LB) to many years old leys (8–12 years) (LC) up to permanent meadows P. In 1987 studies were carried out in meadows of sequence located in outwash plain ($LB_{2(4)}$, $LB_{2(6)}$, LC_2 and P_2) and in sequence 3 located in the slopes of the river valley (LB_3, LC_3, and P_3). In 1988 and 1989 the meadows involved were and LA, LB, LC, P (located in outwash plain) and P_3 (located in the slope of river valley) (Table 1). The study sites were excluded from the grazing by cattle.

3. METHODS

The weighing method to assess breakdown and the litter bag technique are widely applied in research of decomposition processes (Jakubczyk 1976, Seastedt 1984).

The input material was *Dactylis glomerata*, which was obtained from field cultivation at the ear production stage. Species purity was estimated at 98%. Plants collected after cutting were air dried for 7 days and then weighed into litter bags in amount such that each contained 10g dry mass of plant material. Weight analysis of control samples (dried at temperature of 105° C for 4 hours) revealed an error for weighings done in this way of d = 0.11. The bags used were of 1 mm steelon mesh with dimensions of 14 × 12 cm (area of contact with the substratum – 200 cm^2). The weighed *Dactylis glomerata* was enclosed within them. One side of each bag had six apertures left of lenght of about 1 cm in order to allow invertebrate fauna to penetrate the plant material. The bags with grass were laid out in mesocosms of experimental design presented in Kajak (1997), in such a way that their surfaces made direct contact with the soil. Bags were laid out on the studied meadows in spring, in quantities ensuring that it was possible to collect a series of 5 to 10 at each sampling time. On the different meadows bags were laid out in a linear arrangement every 1.5–3 m. Depending on the size and shape of the meadow and the exposition of the slope, this was one series placed in the centre of the meadow (where meadows were long and flat) or in several parallel series (across the slope for sloping meadows).

Bags for measurements were collected from the different series according to the principle of even cover of the study area, i.e. every n-th relatively to the number of litterbags in the row and the frequency of sampling in the field. The time of successive samplings of bags are given in Tables 2 and 3.

A field experiment was carried out to measure litter decomposition rate on the same underlying substrate in every meadow. In every experimental site 90 sand (sd) filled holes each with surface area 200 cm^2 and a depth of about 30 cm, were placed. Such holes were arranged in rows, in such a way that the distance between rows was 1 m and the distance between points 0.5 m. Bags with the litter were laid out on half of them, with the same bags being laid out about 30 cm away from each measurement point on local soil (so). Samples to measure the rate of decomposition were taken in accordance with a random order selected earlier.

The material collected was air dried and then dried at a temperature of 105° C four hours before being weighed. The rate of litter loss was estimated with the aid of the ln Wiegert and Evans formula:

$$r = \frac{\ln (Wt_0/Wt_1)}{t}$$

where r – daily rate of decomposition in mg g^{-1} d^{-1}, Wt_0 – initial weight in g, Wt_1 – final weight in g, and t – time of duration of the experiment in days (Wiegert and Evans 1964).

Table 1. Parameters of meadows chosen for the study of litter decomposition in 1987–1989

Succesional[a] sequence	Type of meadow[b]	Year of study			Management	Age of meadow (years since establishment)	Slope	pH of soil in genetic horizon A_1 after Łakomiec et al. 1991	Location in landscape	Vegetation cover in the first year of use
		1st	2nd	3rd						
						outwash plain				
I	LA	–	+	+	ley	2	~ 0°	6.3	mid-field meadow near row of planted trees	*Dactylis glomerata*
	LB	–	+	–	ley	5	~ 0°	6.4	mid-field meadow	*Dactylis glomerata*
	LC	–	+	+	ley	8	~ 20°	5.7	meadow at edge of row of planted trees	*Dactylis glomerata*
	P	–	+	+	permanent meadow, very limited grazing	>20	~ 40°	4.4	meadow at edge of row of planted trees	
						outwash plain				
II	$LB_{2(6)}$[c]	+	–	–	ley	6	~ 5°	–	mid-field meadow	*Phleum pratense*, *Trifolium* sp., *Dactylis glomerata*
	$LB_{2(4)}$[c]	+	–	–	ley	4	~ 5°	5.9	mid-field meadow	*Phleum pratense*, *Dactylis glomerata*, *Trifolium* sp.

	LC$_2$	+	–	–	ley	12	~ 5°	4.3	mid-field meadow	*Dactylis glomerata*
	P$_2$	+	–	–	permanent meadow, burnt intensively every few years, pasture	>15	~ 0°	4.0	mid-field meadow on edge of elevation	
						river valley				
III	LB$_3$	+	–	–	mown, sown	7	~ 15°	3.9	mid-field meadow on undulating terrain	*Dactylis glomerata*
	P$_3$	+	+	+	permanent, intensive grazing	>20	~ 40°	4.1	meadow on slope (sheltered on three sides,plantations)	

[a] successional sequence of meadows from newly established via many-year-old to permanent; [b] age categories of meadows in years: LA – 1–3, LB – 4–7, LC – 8–12, P – permanent; [c] 4 and 6 year old meadows on site LB$_2$.

Table 2. Mass of remaining litter (g dry wt ± SD) laid out 4 June on meadows differentiated by the age and management in 1987. Denotations of meadows as in Table 1

Sampling date	Type of meadow					
	$LB_{2(4)}$	LB2(6)	LB_3	LC_2	P_2	P_3
10 July	3.84 ± 0.82	5.31 ± 0.36	4.22 ± 0.30	4.45 ± 0.53	4.80 ± 0.59	3.74 ± 0.87
8 Octob.	2.53 ± 0.55	3.0 ± 0.17	2.44 ± 0.38	2.29 ± 0.34	2.70 ± 0.45	2.40 ± 0.38
5 Nov.	2.04 ± 0.31	2.79 ± 0.29		2.22 ± 0.48	2.37 ± 0.38	2.14 ± 0.41

The significance of differences between partiular meadows was estimated by the Student test "t". The coefficient of variation V = $s/\bar{x} \cdot 100$ (s – standard deviation, $\bar{x}$ – mean) was used to estimate the variability of the litter weight loss.

4. RESULTS

4.1. LOSS OF LITTER WEIGHT DURING THE GROWING SEASON

The meadows studied were very diverse on account of the relief of the landscape and the intensity of agricultural treatments in the years preceding the study. In spite of this, all sites were found to have similar trends where the changes in the weight loss rate of litter in the course of the experiment were concerned. In general, in all sites a greater loss of litter in the initial period of decomposition than in the later period was found (Table 2 and 3).

In 1987, when the greatest number of sites (6) were studied the mean rate of litter loss was found to be almost twice as high in the first month (47 ± 7.5%) of the experiment (spring) as in the course of the four successive months (15 ± 3%) (summer). The greatest differences in the rate of decomposition on different meadows were noted in autumn. The values of weight loss on meadows $LB_{2(4)}$ and LC_2 amounted respectively to 20% and 5% (Fig. 1.).

There was thus a clear trend for the rate of decomposition on the meadows studied to be lower in autumn than in spring and summer.

4.2. THE LOSS OF LITTER WEIGHT AGAINST THE LANDSCAPE DIFFERENCES IN THE MEADOWS

Landscape differences affect the decomposition rate of litter. This observation was true of both meadows situated on slopes and those differing in the chemical properties of their soils.

The daily rate of litter loss at the foot of the slopes (meadows P and P_3) was significantly greater (11.7) than at the tops of the slopes (8.9) ($p < 0.02$, $n = 22$). The trend for the two sites towards greater variability in the decomposition of litter at the top of the slopes (30%) than at the foot of the slopes (26%) was also found.

Table 3. Mass of remaining litter (g dry wt ± SD) on different type of meadows in 1988–1989 (sd – on sand, so – on soil, X, Y, Z – top, middle, foot of slopes). Denotations of meadows as in Table 1

Date of laid out	Sampling date	Type of meadow												
		LA		LB		LC		P				P_2		
		X sd	X so	X sd	X so	X sd	X so	X sd	X^a so	Y so	Z so	X^a so	Y so	Z so
17 May 1988 (LA,LB,LC)	24 July 88	6.80 ±0.62	5.70 ±0.20		5.74 ±0.60	5.74 ±0.46	5.46 ±0.66							
15 July 1988 (P,P_2)	7 Sept. 88	5.72 ±0.36	5.29 ±0.68	6.88 ±0.55	5.02 ±0.86	5.18 ±0.18	5.10 ±0.25		4.90 ±0.10	4.50 ±0.60	4.40 ±0.52	5.76 ±0.68	5.46 ±0.60	4.54 ±0.30
	10 Oct. 88	5.30 ±0.35	4.26 ±0.34	6.42 ±1.05	4.54 ±0.61	4.68 ±0.13	4.26 ±0.60		3.16 ±0.76	3.80 ±0.17	3.90 ±0.56	4.28 ±0.50	4.14 ±0.80	3.74 ±0.43
	24 Jan. 89		4.14 ±0.29	5.35 ±0.39	4.19 ±0.40	4.41 ±0.62	3.74 ±0.70			3.44 ±0.65			3.31 ±0.32	
10 May 1989	8 June 89	7.08 ±0.93	6.30 ±0.53			7.95 ±1.22	6.74 ±0.70	8.04 ±0.41	7.26 ±0.68					
	15 July 89	6.74 ±1.03	6.21 ±0.59			7.82 ±0.66	6.42 ±0.45	8.03 ±0.67	7.23 ±0.70					
	18 July 89											4.97 ±0.72	4.76 ±0.96	4.28 ±0.76
	24 July 89	6.54 ±0.78	5.68 ±0.66			6.66 ±0.22	5.88 ±0.37	7.42 ±0.65	6.44 ±0.84	5.19 ±0.12	43.44 ±0.49			
	8 Aug. 89									4.97 ±0.07	4.23 ±0.55	4.11 ±0.59	3.97 ±0.80	3.06 ±0.54
	10 Aug. 89	5.09 ±0.54	4.91 ±0.59			5.72 ±0.62	5.09 ±0.31	6.34 ±0.75	5.54 ±0.69					
	10 Oct. 89	4.61 ±0.75	3.37 ±0.43			5.33 ±0.37	3.96 ±0.64	5.47 ±0.94	4.88 ±0.88	3.07 ±0.20	3.07 ±0.16	2.83 ±0.36	2.33 ±0.28	1.64 ±0.50

[a] only the date from the top of the slopes (X) were used for comparison of all the sites.

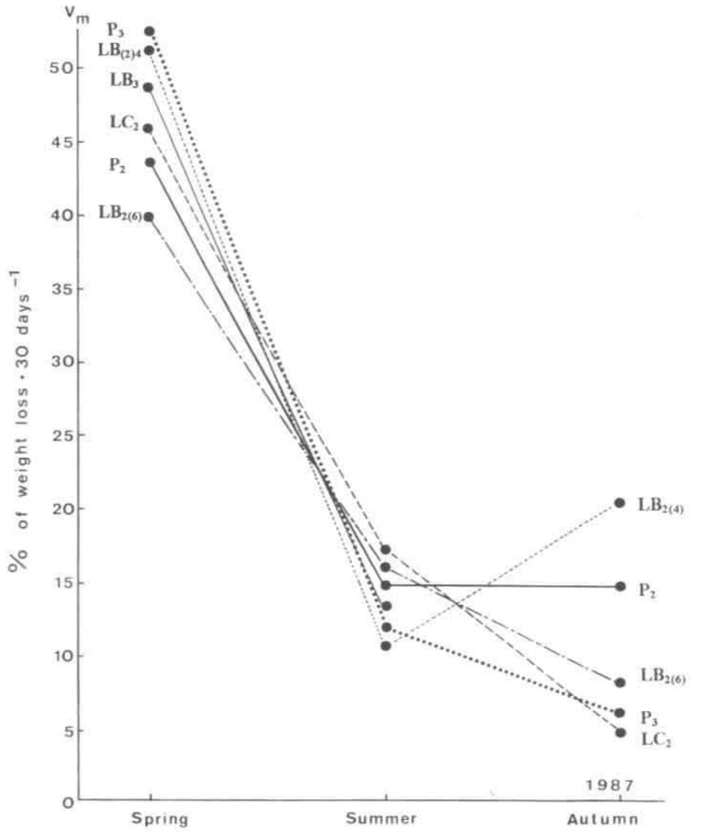

Fig. 1. Seasonal dynamics in litter loss as % of weight loss × 30 days^{-1} on meadows in 1987. Denotations of meadows as in Table 1

A significant parameter modifying the process of decomposition of single-species litter was the acidity of the soils, which ranged from 3.9 to 6.4 in the 9 meadows. Higher pH of the substrate was associated with significantly lower daily rates of litter loss in the growing season (Fig. 2). In 1988, litter was laid out on meadow P and P_3 about two months later than on the other meadows. An extrapolation was thus applied which levelled out the influence of the later distribution of litter on the two meadows. A higher values were obtained for this reason.

The influence of soil moisture on grass litter decomposition in the growing season was found to be of differing intensity in the different years. An important factor that could interfere decomposition rate found in particular years are changes in site location in 1987 and successive years. In 1987 and 1989, soil moisture ranged from 9.9 to 21.3% by weight (Stefaniak et al. 1997b, and unpublished). This variable was not found to be different between two years of study ($p < 0.5$, $n = 30$). The means for soil moisture were 14.7% in 1987 and 15.9% in 1989. In turn, both of these years differed significantly in the rate of litter loss, which was higher in 1987 (17.9) than in 1989 (8.8) ($n = 21$, $p < 0.001$). For this reason each year was analysed separately. In 1987 the relationship between the moisture of the substratum and the rate of litter loss was not significant ($r = 0.11$, $n =$

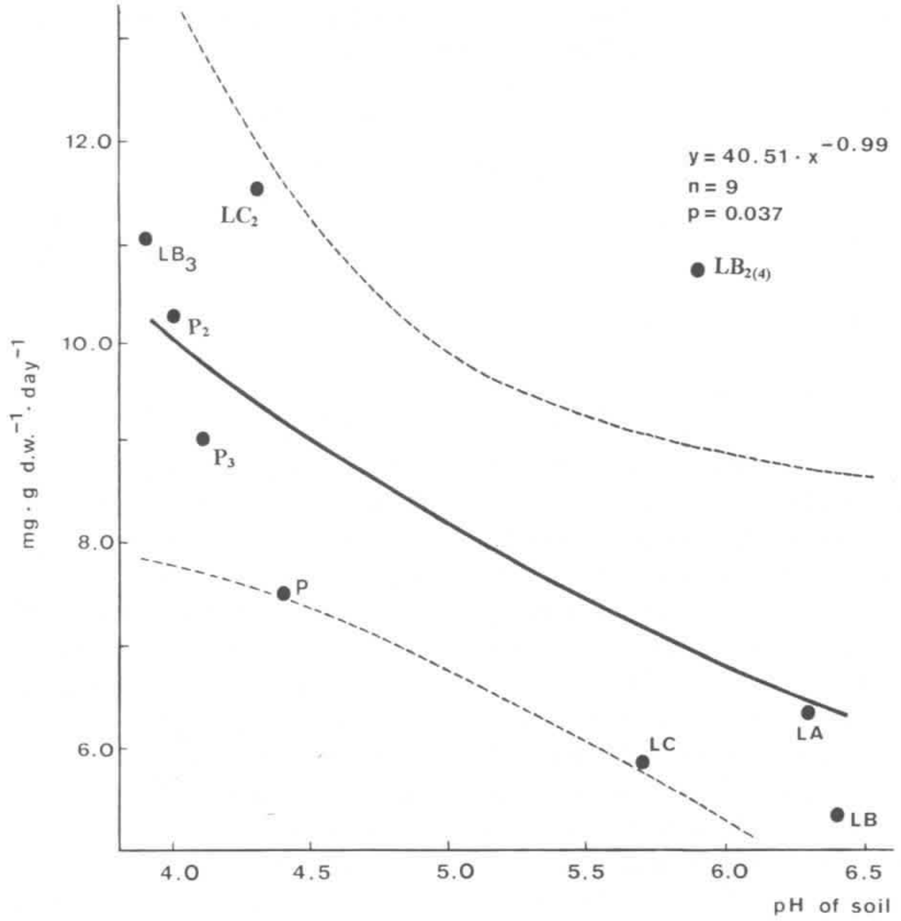

Fig. 2. Dependence of mean daily rate of litter weight loss (mg g dry wt $^{-1}$ day^{-1}) on meadows on soil acidity(pH values after Łakomiec et al. 1991). Denotations of meadows as in Table 1

12, $p < 0.7$). In contrast, in 1989, the relationship was significantly positive ($r = 0.66$, $n = 9$, $p < 0.05$).

On the basis of the above data, it may be considered that, in the range of soil moisture found in the growing season, location in the landscape and chemical properties of the soil modified the process of the loss of litter lying on meadow surfaces to a greater extent than does the soil moisture.

4.3. THE LOSS OF LITTER WEIGHT AGAINST THE AGE AND METHOD OF UTILIZATION OF MEADOWS

In general, older meadows had lesser variability in the daily rate of the loss of litter in the growing season (Table 4). This effect was clear in the years 1988 and 1989. The highest variability in the rate of the loss of litter was noted in the youngest meadow (LA) and the lowest in permanent meadow (P_3). This phenomenon was not marked in 1987. Meadow P_3 witnessed a clear decline in the variability of litter loss over the three years of experiment. It must be pointed out that in the cases of meadows situated on the

Table 4. Variability (σ/x%) in litter weight loss in growing season on meadows in 1988–1989. Denotations of meadows as in Table 1

Period of study	Type of meadow									
	LA	LB	$LB_{2(4)}$	$LB_{2(6)}$	LB_2	LC	LC_2	P	P_2	P_3
1987 June – October			42	32	37		33		42	34
1988 June – October	21	18				20		11		9
1989 May – October	38					34		35		9

slopes only sites lying on the tops were compared with the other ones.

Evaluation of the index of variability shows that older meadows (P, P_3) with progressively more limited agricultural practices are characterized by a certain stabilization in the rate of litter loss.

On the other hand, it is more difficult to find the relationship between the daily rate of litter loss and meadow age. In the years 1988–1989 the sequence of neighbouring and variously-aged meadows situdied was LA, LB, LC, P. In the first year of the experiment, grass was put out two months later on the permanent than on the younger ones. In consequence, the permanent meadow P was not compared with the younger ones in that year. The mean rate of decomposition on younger meadows was lower in 1988 than in 1989, with the coefficient of Wiegert and Evans (r) being 7.0 in 1988 and 8.5 in 1989. In the first year there was great variability in the rate of litter loss in different months. This was independent of meadow age and variable for each site (Fig. 3). Only in the second year of the experiment it was possible to show clear differences between sites.

In the 1988 growing season, there were similar mean rates of mineralization on the new meadow in the first year of cultivation (LA) and on the many-year-old-meadow (LC). The lowest value for coefficient r was displayed by the several-year-old meadow while the highest value was recorded for the permanent meadow (P). In 1989 (when the litter on all meadows was laid out at the same time) there was a clearly lower rate of decomposition on progressively-older meadows (Fig. 3, Table 5). The dynamics of changes during the season in the rate of litter decomposition took a similar pattern on all the meadows in the sequence in that year. Significant differences were noted between all sites in every sampling time. The oldest meadow (P) with its well developed and floristically rich vegetation cover consistently showed the lowest values for the rate of decomposition (Fig. 3, Table 5). The many-year-old meadow (LC) was characterised by intermediate values of r, while the youngest meadow (LA) always had the highest r value in relation to meadows LC and P. The highest r values were noted on permanent intensive pasture P_3 although it was excluded from grazing during the investigation period.

The influence of meadow age on the rate of mineralization of litter was analysed on the basis of data from meadows of similar acidity and of material similar from the point of view of the time of litter exposure. Eliminated in this way was the influence of other important factors which

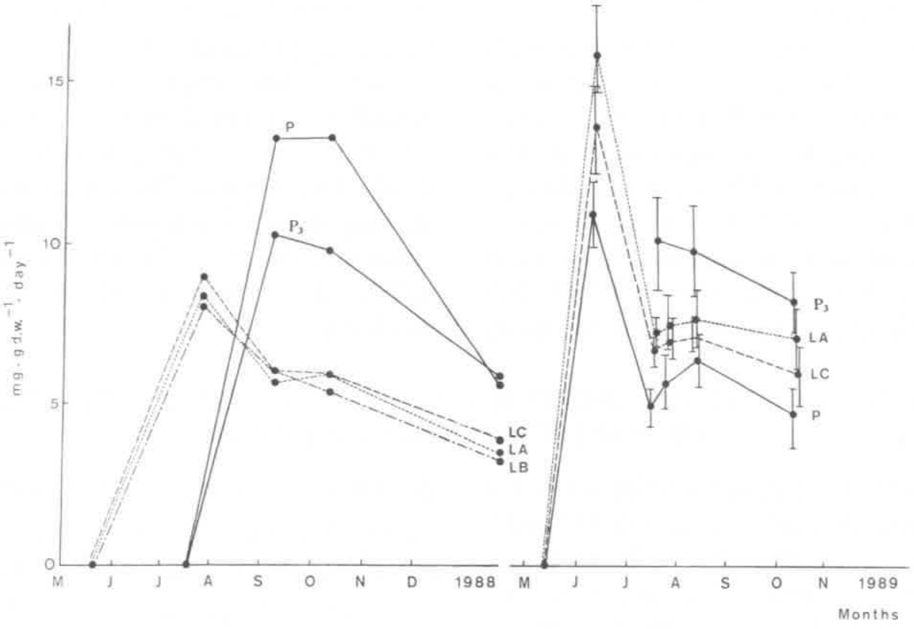

Fig. 3. Seasonal changes in daily rate of litter weight loss (mg g dry wt^{-1} day^{-1}) on soil surface of differently aged meadows. Denotations of meadows as in Table 1

Table 5. Mean daily rate of litter weight loss (mg g dry wt^{-1} day^{-1}) in growing season on meadows in 1987–1989. Denotations of meadows as in Table 1

Period of study	Type of meadow									
	LA	LB	$LB_{2(4)}$	$LB_{2(6)}$	LB_2	LC	LC_2	P	P_2	P_3
1987 June – October 127 days			10.8	9.5	11.1		11.6		10.3	11.2
1988 June – October 147 days	5.8	5.4				5.8		10.5* 13.2[1]		7.7* 9.7[1]
1989 May – October 154 dys	7.1					6.0		4.7		8.2

[1] July – October, 87 days

* calculated r basing on stable changes in litter loss during growing season in total study period.

could have distorted the picture obtained. All the permanent meadows and some of the many-year-old ones were found on acid soils (pH 3.9 – 4.4). Thus the mean r values for meadows of group P were compared with those for the many-year-old meadows (LB_3 and LC_2). The mean value for the permanent meadows were lower than for the many-year-old meadows (7.6, 10.3 and 9.0 for sites P, P_2 and P_3, and 11.1 and 11.6 for LB_3 and LC_2).

The permanent meadows (P and P_3) are characterized by a decrease in the mean value of r in three successive years in comparable decomposition periods (Fig. 3, Table 5). On meadow P this decrease amounted to 64% in the course of two years, while on meadow P_2, the mean in the course of three years fell 29%. This was all the more interesting for being confined to permanent meadows, as the opposite trend was observed in the period on the younger meadows.

Thus, older meadows show reduced variability in the processes of decomposition of litter as well as a declining trend for the loss of grass. The cessation of all mowing and grazing practices is also followed by a decline in the rate of mineralization, as observed on permanent meadows.

4.4. LOSS OF LITTER WEIGHT ON SUBSTRATUM (SAND) INSERTED ON VARIOUSLY AGED MEADOWS

A field experiment carried out on the sequence of meadows LA, LB, LC and P showed a fundamentally different course of decomposition on inserted sand into the soil profile when compared with the soil. The rate of litter decomposition at all sites was clearly lower on sand than on soil (Table 3, Figs 3 and 4). Despite the difference in the course of litter loss on different substrates it was found that decomposition on sand clearly reflected the course of litter loss within each site (Figs 3 and 4). Thus the differences between sites were the same in the situation when both kind of substrata were used.

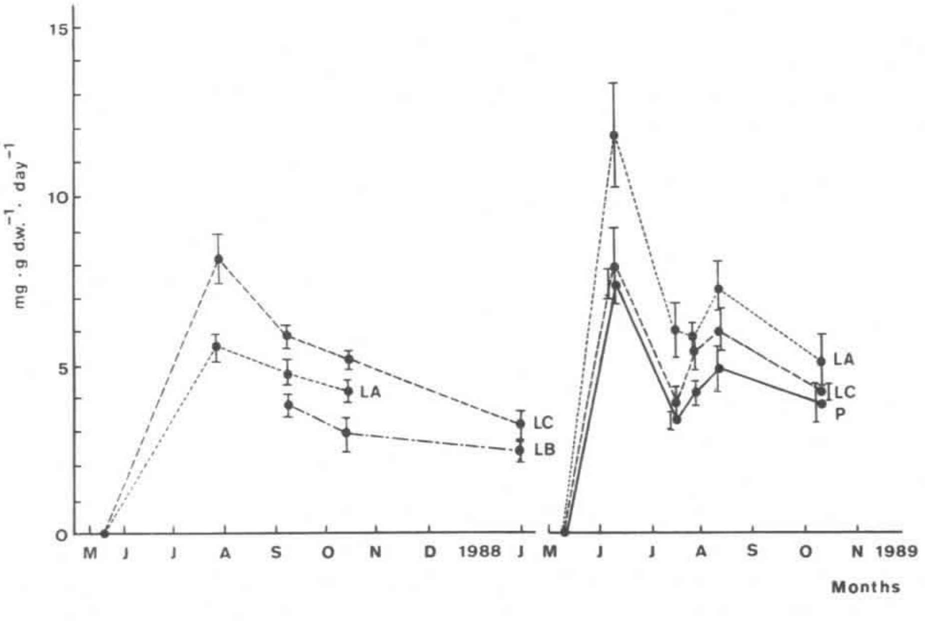

Fig. 4. Seasonal changes in daily rate of litter weight loss (mg g dry wt^{-1} day^{-1}) on simplified substratum (sand) of inserted in differently aged meadows. Denotations of meadows as in Table 1

5. DISCUSSION

The aim of the research was to assess the influence of diverse environmental factors and of the age of the meadows on the decomposition of grass litter.

The seasonal mean value of the daily rate of litter loss amounted to 8.8 ± 2.7 mg g day^{-1} (n = 15 for three years, range 5.4 – 13.2). This is within the limits of values for the loss of grass litter given for meadows of central Poland by Jakubczyk (1976). In turn values resemble the data obtained by Jakubczyk (1976) in being significantly higher than those given for meadows in the Czech Republic (6 sites; lowland and mountain) by Rychnovská (1993). All these data were also obtained by the litter bag method, in the growing season, albeit with 0.3 mm netting as compared to the 1 mm netting used in the present research. However in spite of using netting of larger (1.5 mm) mesh, Tesařová 1977 (after Úlehlová 1985) also obtained a lower rate of litter loss than in our case on several lowland sites. Values for the loss of grass litter on the meadows of SLP, expressed in % monthly losses, are similar to those obtained for meadows of the Arrhenatheretalia order by Pomianowska-Pilipiuk (1976) and Łomnicki and Bandoła (1967).

A considerably faster decomposition of grass in the initial period, irrespective of the actual time of introduction, is linked with the leaching and mineralization of readily soluble components in the litter (Swift et al. 1979). The lower rate of decomposition associated with older meadows has been confirmed on the same sites by Petrov in 1990 (unpublished) and by Stefaniak et al. (1997b) who found lower abundance of microflora in the litter exposed in permanent meadow than in younger ones. In addition, the greater stabilization of microbial activity along the age gradient of meadows (Stefaniak et al. 1997a) is accompanied by a clear decline in the variability of the rate of decomposition of cocksfoot. The microflora has a significant effect in modifying the course of the decomposition of grass litter. Confirming this are the researches of many other authors (e.g. Curry 1969, Malone and Reichle 1973, Jakubczyk 1976).

Very interesting in this context is the issue of the significant negative relationship between the decomposition rate of litter and soil pH. It would seem that there was a bioindicative effect linked with the distribution everywhere of the same litter. Mainly on the basis of laboratory research, Jenkinson (1977) and Hopkins et al. (1990), held that the decomposition rate of grass litter was retarded by acidified soil in relation to that with near neutral pH. The latter authors stated that the raising of soil pH in microcosms increased the rate of mineralization of litter to only 60% of the value seen in soil of near neutral pH (pH – 5.3). They therefore suggested (despite the lack of parallel research on soil fauna) that the absence of animals in acid soils could lead to reduced decomposition.

The potentially high level of activity of soil organisms in very acid environments was probably revealed. The substrate constituted of by grass has a narrow range of C/N ratios (Mochnacka-Ławacz 1978, Swift et al. 1979) and may be utilized by a cosiderably wider spectrum of soil fauna. Curry, Kelly and Bolger (1984 after Bolger 1985) give the example of a plantation of aspen on a newly recultivated raised bog (pH = 7), where in the absence of earthworms, springtails and mites served the function of first order saprophages in the decomposition of aspen foliage. In the present studies, permanent meadows were characterized by highly acid soils and by low values for litter loss with microfloral activity at these sites weaker than on the new or many-year-old ones. Data of Stanuszek (1997) also show the less effective use of experimental litter as a food base by nematodes on the permanent meadow than on the younger ones.

The role of soil saprophages in litter loss in investigated sites is difficult to assess in a view that parameters such as landscape situation of meadows, chemical and moisture conditions were the factors which greatly influenced the litter loss. Hence the role of soil fauna in litter decomposition in SLP deserve more investigations to be carried in such diversified area.

It was interesting to note that permanent meadows had lower decomposition rate of grass litter compared to grass leys. This is undoubtly a result of the cessation of grazing carried on at varying intensity on these meadows. Kotańska (1977), Hassink (1992) and Siepel and van Wieren (1990) found a distinctly more rapid process of mineralization in soil and in distributed litter where sites were grazed as opposed to being ungrazed or in the first period after the cessation of grazing. The influence of grazing in the year prior to the commencement of the experiment on the rate of decomposition of grass at permanent sites would seem to be important. This remark is also true of younger meadows.

The use of a sand substratum in experimental studies on the decomposition of grass allowed for the clear presentation of differences between sites and within the season. The litter loss on sand reflected the course of decomposition of litter on soil within each site.

6. CONCLUSION

1. Irrespective of the time that grass litter was exposed, decomposition on all meadows studied was most intensive in the initial phase of decomposition (1–2 months), and slower in the next 3–4 months.

2. Relief had a significant influence on the rate of decomposition of litter. The loss of grass material occured more rapidly on meadows at the foot of slopes than on those found at the tops.

3. The loss rate of litter weight slowered with the increase of soil pH. Sites arranged in the order of pH from 3.9 to 6.4 were characterized by reduced daily rates of litter decomposition in the growing season.

4. Along the successional sequence of meadows from the most recently established to the permanent there was decline in both daily rates of mineralization in the growing season and to the lesser extent the degree of variability of these rates.

5. The cessation of grazing on the experimental parts of permanent meadows was followed in successive years by a decline in values for the daily rate of loss of litter.

7. SUMMARY

The investigations were carried out in the years 1987–1989 in Suwałki Landscape Park, on meadows differing in terms of location in landscape and in terms of successional age (from a one-year-old meadow (LA) via several-year-old (LB) and many-year-old (LC) meadows to permanent meadows (P) (Table 1). The aim of the research was to define the influence of secondary succession on meadows on the processes of mineralization of single species grass litter of cocksfoot (*Dactylis glomerata*). A field experiment was carried to measure litter decomposition rate on the same underlying substrate in some meadows (1988–1989). In every experimental site 90 sand filled holes each with surface area of 200 cm^3 and the depth of about 30 cm, were made. Bags with grass litter were laid out on the sand as well as on the surrounding soil on all sites including those where experiment with exchanged substratum was not carried. Experimentation was done on ungrazed plots. The litter loss was assessed by weighing the collected samples. The 10 meadows studied were of the order Arrhenatheretalia (Table 1). The characteristic feature of the meadows studied is the decline in the proportion of *Dactylis glomerata*, and of increase of in the numbers of other species, along with the aging of meadows and the increase in the content of organic matter in the soil. The meadows were on true brown earth. To minimize the effect of the diversity of the terrain on the processes of succession, series of several contiguous meadows were selected in 1988 and 1989.

The rate of litter decomposition was almost twice as high in spring as in summer and showed a downward trend in autumn (Fig. 1, Table 2.). The location of a meadow in the landscape had a significant influence on the rate of the litter loss. In the two sequences on slopes there was significantly greater litter loss at the foot of slopes than at the tops ($p< 0.02$) (Table 3). Lower pH values for the soil were associated with greater litter weight loss (Fig. 2). The indicatory effect revealed in this case was linked with the application at all sites of a uniform decompositional material with a narrow range of C/N ratios. The influence of soil moisture on the rate of decomposition of grasses was variable in different meadows in different years of the study – not significant in 1987 and significant and positive in 1989 ($r = 0.66$, $n = 9$, $p < 0.05$).

In spite of the strong influence of the landscape on the variability in litter weight loss it was possible to note an influence of meadow age on the process. Older meadows had both lower variability in the loss of *Dactylis glomerata* litter (Table 4) and a lower rate of decomposition (Figs 3 and 4, Table 5). A similar effect was obtained when the rates of litter weight loss on meadows with highly acid substrata were compared (Fig. 2). Permanent meadows were found to have declining rates of decomposition in successive years of study (Fig. 3, Table 5).

The weight loss of litter on a simplified substratum progressed slowly, but clearly reflected the course of the decomposition of litter on soil within each site (Figs 3 and 4).

8. POLISH SUMMARY

Badania przeprowadzono na silnie zróżnicowanych wiekowo (od jednorocznej – LA poprzez kilkuletnie – LB, wieloletnie – LC i trwałe – P) i krajobrazowo łąkach Suwalskiego Parku Krajobrazowego w latach 1987–1989.

Celem badań było określenie wpływu sukcesji wtórnej na łąkach na procesy mineralizacji jednogatunkowej ściółki trawy kupkówki pospolitej (*Dactylis glomerata*). Badano 10 łąk z rzędu Arrhenatheretalia na poletkach odgrodzonych od wypasu i koszenia (tab. 1). Cechą charakterystyczną badanych łąk jest spadek udziału *Dactylis glomerata* i wzrost liczby innych gatunków wraz ze starzeniem się łąk oraz wzrost zawartości substancji organicznej w glebie. Badane łąki znajdowały się na glebach brunatnych właściwych. Aby zminimalizować efekt różnorodności terenu na procesy sukcesji wybrano w latach 1988 i 1989 ciąg kilku łąk znajdujących się w bezpośrednim sąsiedztwie.

Badania rozkładu ściółki prowadzono metodą woreczkową. Ponadto zastosowano punktową wymianę podłoża na wyżej wybranym ciągu, dając piasek w celu porównania zmian w rozkładzie ściółki na jednakowym dla wszystkich łąk podłożu.

Tempo rozkładu ściółki było prawie dwukrotnie wyższe na wiosnę względem lata i

wykazywało tendencję spadkową na jesieni (rys. 1, tab. 2).

Stwierdzono, że usytuowanie łąk w terenie istotnie wpływało na tempo mineralizacji ściółki. W dwóch ciągach na zboczach stwierdzono istotnie szybszy rozkład ściółki u podnóża zboczy w porównaniu ze szczytami (tab. 3) na poziomie $p < 0,02$. Ze spadkiem wartości pH gleby zwiększał się ubytek ściółki (rys. 2). Ujawnił się w tym przypadku efekt wskaźnikowy związany z zastosowaniem jednakowego na wszystkich stanowiskach materiału rozkładowego o wąskim stosunku C/N. Wpływ uwilgotnienia gleby na tempo rozkładu ściółki był zmienny na poszczególnych łąkach w różnych latach badań, – nieistotny w roku 1987 i istotnie dodatni w roku 1989 ($r = 0,66$; $n = 9$; $p < 0,05$).

Mimo silnego wpływu krajobrazu na zmienność rozkładu ściółki stwierdzono wpływ wieku łąk na ten proces. Wraz ze starzeniem się łąk wystąpił zarówno spadek zmienności ubywania kupkówki (tab. nr 4) i tempa rozkładu ściółki (rys. 3 i 4, tab. 5). Podobny efekt zaznaczył się przy porównaniu tempa rozkładu na łąkach o silnej kwasowości podłoża (rys. 2). Na łąkach trwałych ujawnił się spadek tempa rozkładu (rys. 3, tab. 5) w kolejnych latach badań.

Rozkład ściółki na podłożu uproszczonym przebiegał wolniej, lecz odzwierciedlał w sposób wyraźniejszy przebieg rozkładu ściółki na glebie w obrębie każdego stanowiska (rys. 4).

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